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THE ANNUAL MEETING

The annual meeting of the Potato Association of America will be held in Boston on December 28, 29 and 30. The Avery Hotel has been assigned as headquarters for the Association and the meetings will be held in the Biological Laboratories, Harvard University. Rates at the Avery are $2.50 to $4.00 for single rooms and $3.00 to $5.00 for double rooms, with bath. The Avery will also be the headquarters of the American Society of Agronomy.

The program has not yet been completed but a joint session with the American Society of Agronomy is being considered for Thursday, December 28, to discuss field and microchemical methods for determining soil deficiencies. This discussion should be of value to all interested in the plant food requirements of the potato. The two sessions on Friday will be devoted to miscellaneous papers. The Saturday morning session will be devoted to a discussion of marketing methods and also the proposal that the potato industry be placed under the Agricultural Adjustment Act. On Saturday afternoon a joint session has been arranged with the American Phytopathological Society to discuss disease problems.

It is anticipated that there will be a thorough discussion of seed potato certification standards at this meeting. This year, several states have modified their standards and others are planning to do so next year. It is hoped that the Boston meeting will see the adoption of a set of standards that will be satisfactory to all the states. Another point which should receive careful attention at this time is the proposed plan to "balance production and consumption at equitable prices to both consumer and producer through an adjustment of acreage." The meeting at Boston should afford an opportunity for the Eastern potato growers to discuss this very important question. There should be a good attendance of those interested in the potato crop at this meeting.

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Volume X November, 1933 Number 11

THE EFFECT ON VIGOR AND YIELD OF STORING CUT POTATO SETS*

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Little experimental evidence as to the value of stored cut potato sets had been reported when these studies were begun and, for the most part, it was in disagreement. Considerable attention, however, probably influenced greatly by the detailed study of disease infections of bruised tubers and planted sets, has been given to the problem in late years.

The early investigations reported by Goff (1) and Reed (2) favored the use of sets cut in advance of the planting season. Those reported by Foster (3), Osterspen (4), Carden (5), and Harrington (6) showed the freshly cut sets to be better. The more recent work of Lombard (7), Wright and Peacock (8), and Clayton (9) clearly indicate that cut sets given treatments properly to heal the injured areas prior to storage often give greater yields than sets cut immediately before they are planted.

Appel (10) in 1906 and Shapovalov and Edson (11) in 1919 showed that only under conditions of moderate temperature and high humidity did wound periderm form on the cut area of the potato tuber. Priestley and Woffenden (12) in 1923 and Priestley and Johnson (13) in 1925 studied and described in detail wound periderm formation and suberization. A temporary blackening of the cut area is formed in the first 48 hours by the deposit of suberin from the oxidation of fatty acids. This is followed by the formation of a new periderm several cells in thickness below the blackened area, which, dependent on conditions, may or may not become suberized. If the cut area is exposed to sunlight for a time, the suberin deposit is lacking and the susceptibility to disease is greater. A moist atmosphere with good ventilation is essential for a continuous layer of suberin, while dry atmospheric conditions result in incomplete or "patchy" suberin deposit.

* Published with the approval of the Director, West Virginia Agricultural Experiment Station, as Scientific Paper No. 123.

The more recent studies of Weiss, Lauritzen, and Brierley (14) relative to Fusarium infection of the tuber, and the somewhat similar investigations of blackleg by Leach (15) define clearly the conditions under which the development of a protective periderm and suberization occurs, also the part this suberized tissue plays in the complete sealing of the injured area against tuber infection.

Weiss, his coworkers and Artschwager (16) studied the rapidity with which six of the standard commercial sorts of potatoes developed wound periderm and suberization under different conditions of temperature and humidity. They found that none of the varieties used were able to form a well-developed periderm even under favorable humidity conditions at temperatures below 50° F. High relative humidities were necessary for rapid suberization. The injured areas of Spaulding Rose and Cobbler tubers healed most rapidly, those of the Russet and White Rurals slowest, while injured Green Mountain and Triumph tubers were intermediate in this respect.

This brief survey of the literature suggests that the early workers, to whom only the ordinary home types of storage were available, found it difficult to carry on systematic detailed studies of the factors involved and, for the most part, obtained conflicting results. Those who have more recently given attention to the problem, aided by advanced knowledge and improved equipment, have shown that cut potato sets properly treated can be stored well in advance of the planting season.

The experiments herein reported were in progress during the storage and growing seasons of 1921–22, 1922–23, 1926–27, 1927–28, and 1928–29 and had for their purpose (a) a comparative study of conditions and weight losses from shrinkage, rots, and other causes between cut and whole tubers at regular intervals during the storage period, and (b) the determination of the length of time that potato sets cut in storage could be kept there without impairing vigor and yield.

Potato seedstocks of the Rural variety were used in all the studies, and in each instance the storage period started within a relatively short time after harvest. A temperature of approximately 40° F. and a relative humidity ranging between 87 and 93 per cent were maintained throughout the storage period each year in accordance with the recommendations of Butler (17), which have since been substantiated by the studies of Stuart, Lombard, and Peacock (18).

An electric fan which blew directly on a large pan of water served to circulate the air and thus more evenly regulated the humidity in all parts of the cooler. The containers used were bushel and half-bushel slat baskets during the first two seasons and wire baskets of about three-quarter-bushel capacity during the remaining studies. The field trials were at the Horticultural Farm at Morgantown the first two seasons, and thereafter on the Arthurdale Farms at Reedsville.

The experimental procedure in these studies was primarily the same each year. To avoid unnecessary repetition, a general description of the methods used will be given at this time, and the details and minor changes made from time to time will be discussed as each year's work is reviewed.

Thirty-pound seedlots were cut at two-week intervals during the storage season with the exception of the first, during which the cutting interval was approximately fifteen days. Check or uncut lots of the same weight were included in the trials. A supply of uncut seedstock of the same strain was set aside to supplement these check lots at planting time. With the exception of the preliminary study of 1921–22 in which the total losses by shrinkage and disease were determined at planting time all seedlots then in the trial were weighed and note was made of their condition at the end of each time interval. Losses occurring due to rots were recorded. All lots were weighed immediately before they were planted.

The planting scheme for the first trials was essentially the same each year. It comprised at least three replications of a planting made up of a single-row plat planted from each of the seedlots in the sequence in which they were cut in storage. Check rows planted from freshly-cut sets occurred at regular intervals throughout the planting. Spacings were uniform, the usual cultural practices were followed, and the necessary precautions to prevent "border influences" were taken. During the growing season the plantings were closely observed, and growth data were taken. At harvest the yields were taken by single-row plats to quarter-pound accuracy.

In the analysis of the harvest data the yields of the plats planted from the stored cut seedlots are compared with the mean yield of the two nearest flanking check plats. The significance of the yield and plant stand differences were determined by Student's method (12), (13).

THE 1921–22 STUDY

Seedlots of a good strain of Smooth Rural seedstock were cut at approximately 15-day intervals from October 17, 1921, to April 24, 1922. Check lots of uncut tubers were added 19, 45, 107, and 135 days after the study began to allow for weight comparisons. Table 1 shows the loss of weight to be rapid, particularly during the first week or so after the tubers were cut, whereas the check tubers lost weight steadily—the accumulative losses being only a quarter to a half as much as those in the case of the cut stock. The sets of the first two seedlots, those longest in storage, were markedly withered and the cut areas discolored, while those sets cut later were comparatively firm and in good condition at planting time. Only a few seed pieces of the first three lots were lost by rotting.

TABLE 1.—*Storage intervals and weight losses from cut and uncut potato seedlots during season of 1921–1922*

Treatment	Cut	Cut	Not cut	Cut	Cut	Not cut	Cut	Cut
Number of days in storage	189	175	170	160	144	144	129	114
Number of days between cuttings		14	5	15	16		15	15
Percent weight loss in storage	13.3	11.7	3.3	11.7	11.7	5.0	11.7	10.0

Treatment	Cut	Cut	Not cut	Cut	Cut	Not cut	Cut	Cut
Number of days in storage	98	82	82	68	54	54	39	23
Number of days between cuttings	16	16		14	14		15	16
Percent weight loss in storage	11.7	9.2	3.3	5.0	5.0	2.5	5.0	3.3

TABLE 2.—*Comparison of total yields from stored cut and freshly cut potato seedstock, 1922*

Planting sequence of treatments	Date of cutting	Number of days cut in storage	Comparison of treatments with mean of nearest flanking checks		
			Mean of yields in bu. per acre	Yield differences in bu. per acre	Odds
Check	4/24/22		203.2		
1	10/17/21	189	96.0	+ 107.2	999
2	10/31/21	175	149.3	+ 53.9	44
3	11/15/21	160	174.3	+ 28.9	11
4	12/1/21	144	205.8	− 2.6	2
Check	4/24/22		221.5		
5	12/16/21	129	138.0	+ 83.5	2499
6	12/31/21	114	147.7	+ 73.8	999
7	1/15/22	98	158.2	+ 63.3	70
8	2/1/22	82	170.3	+ 51.2	51
Check	4/24/22		220.9		
9	2/15/22	68	233.2	− 12.3	6
10	2/27/22	54	225.2	− 4.3	1
11	3/16/22	39	185.6	+ 35.3	31
12	4/1/22	23	178.0	+ 42.9	65
Check	4/24/22				

On April 24, 1922, the field trials were planted on a heavy clay loam soil of fair fertility. These trials consisted of five replications of the basal planting arranged in two tiers or blocks of three series each. The check rows occurred at the beginning, every fifth row, and at the end of each tier or block of plats. The rows were 30 feet in length and spaced 3 feet apart. The sets were about 10 inches apart in the drill.

The time of emergence was about the same on all the plats, and the stand was good with the exception of those rows planted from the two cut seedlots longest in storage. The stand in these last mentioned plats was poorer and the plants appeared to have less vigor. At harvest there was no noticeable difference in the comparative amounts of large and small tubers in the different treatments.

A comparison of the yields, in Table 2, shows the freshly cut seedstock for the most part to have been significantly better. Whenever the yields from the stored cut are greater the differences are slight and of no significance.

THE 1922–23 STUDY

Smooth Rural seed was cut every fourteen days from the beginning of storage on November 6, 1922, until planting time on April 21, 1923—a total of 163 days. A check lot of uncut tubers was included at each cutting with the exception of the last, on April 18. Although none of the cut lots showed undue blackening of the cut area, the cut surfaces of that lot longest in storage was darkest and the sets were less plump and leathery to the touch. During the latter part of February the surface layer of sets in the lots cut December 4 and 18, and January 1 were infected with mold on the cut area; the sets remained dry, however, and apparently no undue loss of weight resulted.

Because of the general similarity in the storage behavior of the seedstocks used in the subsequent studies with that of the first, and to reduce the cost of publication, only the table summarizing the results of the first storage study is given.

The total weight losses from the different cut lots were about the same in this experiment as were those of the study made in the 1921–22 season, if consideration is given to the length of time the cut lots remained in storage. In this study the periodic weight losses of both the cut and check lots gradually decreased throughout the storage season with the cut lots losing about twice as much weight as the check seed. There was no definite period in which weight losses, as indicated by total loss for each seedlot, were particularly large.

A detailed study of the weight loss by 14-day periods of every second cut seedlot and the corresponding check seedlots, summarized in Figure 1, shows most of the seedlots then cut to have gained in weight rather than lost during the period between January 15 and

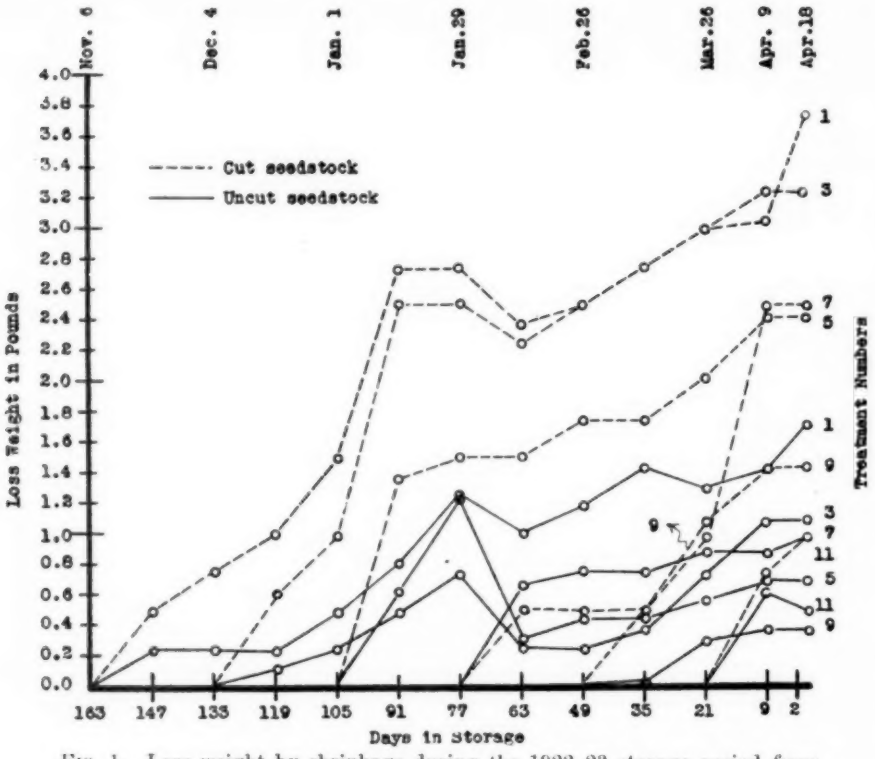

FIG. 1. Loss weight by shrinkage during the 1922–23 storage period from 30-pound cut and uncut seedlots.

February 12. The weights of the corresponding check lots also increased to an even greater degree at this time. A close inspection of the storage records failed to disclose any information as to causes that would contribute to this unexpected behavior. In addition, Table 3 shows that only those seedlots cut on January 29 and February 12 significantly outyielded the freshly cut sets. The yield differences from the other cut seedlots, with the exception of that cut February 26, which gave significantly lower yields than the check seed, were of no importance.

These facts suggest that in this case a change occurred in both the cut and the uncut seedlots which caused them to absorb moisture, and which increased the yields of the sets cut at that time. Yield was evidently only partially affected by weight losses due to shrinkage.

No losses from rots occurred although a few of the thin sets in the cut lots which remained 107, 93, and 70 days in storage, respectively, were removed at planting time as worthless.

All seedlots were weighed on April 18 and planted on April 23, 1923. The planting was similar to that of 1922 except that every third

TABLE 3.—*Comparison of yields of No. 1's and of total yields from stored cut and freshly cut seedstocks, 1923*

Planting sequence of treatments	Date of cutting	Number of days cut in storage	Comparison of treatments with mean of nearest flanking checks					
			Mean of total yields of No. 1's of nearest checks in bu. per acre	Yield differences in bu. per acre	Odds	Mean of total yields of nearest checks in bu. per acre	Yield differences in bu. per acre	Odds
Check	4/18/23		216.7			251.9		
1	11/6/22	163	209.0	+ 7.7	3	249.6	+ 2.3	1
2	11/20/22	149	207.0	+ 9.7	3	251.6	+ 0.3	None
Check	4/18/23		218.7			253.5		
3	12/4/22	135	226.4	− 7.7	2	273.8	− 20.3	8
4	12/18/22	121	231.2	− 12.5	3	266.1	− 12.6	9
Check	4/18/23		199.3			234.0		
5	1/1/23	107	222.5	− 23.2	13	260.3	− 26.3	16
6	1/15/23	93	199.3	None	None	241.9	− 7.9	2
Check	4/18/23		187.2			224.2		
7	1/29/23	79	226.4	− 39.2	1285	267.0	− 42.8	48
8	2/12/23	65	272.8	− 85.6	6999	319.3	− 95.1	1392
Check	4/18/23		187.2			229.3		
9	2/26/23	51	153.8	+ 33.4	59	191.6	+ 37.7	64
10	3/12/23	37	173.2	+ 14.0	3	233.2	− 3.9	1
Check	4/18/23		187.7			228.3		
11	3/26/23	33	220.6	− 32.9	88	264.1	− 35.8	21
12	4/9/23	9	189.6	+ 1.9	1	232.2	− 1.9	2
Check	4/18/23							

row was a check; *i.e.*, each treatment was flanked on either the right or the left by a check row. Seven replications of the basal planting were made. The rows were 30 feet long and spaced 30 inches apart. The distance between sets in the drill was about 10 inches.

Observation just before blossoming time showed the stand to be comparatively even over the entire planting area although no definite counts were made. The yields by grade of single-row plats were recorded.

In Table 3 the comparison of yields of both No. 1's and the total yields from plats planted with seed cut and stored during the first 84 days of the storage period (lots 1 to 6 inclusive), and of yields from those planted with freshly-cut stock failed to give differences which were significant, although there was a general tendency for the stored cut seed to yield more. The yield differences between the lots cut during the last 79 days of the storage period (lots 7 to 12 inclusive) and the freshly-cut stock, are for the most part significant. They show no consistent trend, however, in favor of either kind of treatment.

These 1923 data apparently indicate that if there was any real difference in the seed values of the stored-cut and the freshly-cut stock it slightly favored the former. Since these differences were so inconsistent both in magnitude and in trend, they warrant little confidence.

A comparison of the yield results of 1921–23 (Tables 2 and 3) shows them to be almost in direct contradiction in trend to each other, although the differences in many cases are of little significence.

THE 1926–27 STUDY

Certified Russet Rural seedstock was used in this study. The length of the storage period was 156 days. The seedlots were cut periodically until April 5 and a check lot of whole tubers was included at each cutting.

Loss of cut seedstock in storage occurred in the five seedlots cut first and decreased from 17.4% of the total lot weight in the lot first cut to 2.4% in the fifth lot cut. These lots were more withered and leathery to the touch and at planting time some of the sets that were regarded as unfit for use were discarded. The other cut seedlots were firm and well calloused. In general the cut areas appeared to be thoroughly calloused in three or four days and there did not seem to be much variation in the time required for this to occur, regardless of the part of the storage period in which the cutting was done. There was an observable gradation in intensity of color of the calloused areas in the different seedlots dependent on the length of time the stock remained in storage. Little difference in this respect was evident in the three cut lots remaining longest in storage.

Apparently little difference occurred in weight-loss due to shrinkage in the first four lots cut—those remaining cut in storage from 114

TABLE 4.—*Comparison of yields of No. 1's and of total yields from stored cut and freshly cut seedstock, 1927*

Planting sequence or treatments	Date of cutting	Number of days cut in storage	Comparison of treatments with mean of nearest flanking checks					
			Mean of yields of No. 1's of nearest checks in bu. per acre	Yield differences in bu. per acre	Odds	Mean of total yields of nearest checks in bu. per acre	Yield differences in bu. per acre	Odds
Check	4/21/27		75.1*			136.7*		
1	11/16/26	156	66.3	+ 8.8	15	102.2	+ 34.5	55
2	11/30/26	142	59.2	+ 24.0	96	91.2	+ 49.6	82
Check	4/21/27		83.2*			140.8*		
			85.2*			124.1*		
3	12/14/26	128	61.7	+ 13.5	5	87.0	+ 37.1	32
4	12/28/26	114	65.3	+ 24.9	9	105.3	+ 37.9	10
Check	4/21/27		90.2*			143.2*		
			87.7			141.9*		
5	1/11/27	100	66.1	+ 21.6	22	97.6	+ 44.3	90
6	1/25/27	86	56.8	+ 26.4	26	95.7	+ 39.8	44
Check	4/21/27		83.2*			135.5*		
			90.6*			147.1*		
7	2/8/27	72	77.8	+ 12.8	192	117.8	+ 29.3	188
8	2/22/27	58	90.4	+ 0.2	None	133.6	+ 10.7	3
Check	4/21/27		90.2*			144.3*		
			94.7*			150.7*		
9	3/8/27	44	81.7	+ 13.0	6	130.0	+ 20.7	20
10	3/22/27	30	97.4	− 4.0	4	149.3	− 1.6	None
Check	4/21/27		93.4*			147.7*		
			86.1*			140.4*		
11	4/5/27	16	68.2	+ 17.9	27	122.7	+ 17.7	14

* Planting in several parts which resulted in different combinations of check rows.

to 156 days. The lots remaining cut in storage less than 114 days shrank considerably less, the weight loss decreasing gradually as the time in storage shortened. The shrinkage of the check seedlots was about half that of the corresponding cut lots and likewise gradually became less as the storage period became shorter. Figure 2 shows in detail the weight losses due to shrinkage for every second cut seedlot together with that of its corresponding check. Both the cut and uncut seedlots lost continuously throughout the storage season, the latter, of course, losing least.

The field trials were located on a moderately fertile soil which varied from a light clay to a heavy sandy loam. The planting scheme was the same as that used in 1923. Because of the loss of a portion of the seedstock at planting time from the lots cut November 16, December 14, and February 8 (lots 1, 5 and 15), plats planted from these cut lots appear only in the first four series. There was very little, if any, observable difference in plant stand or in plant vigor between the plats planted with the check and stored cut sets.

The comparison given in Table 4 shows a general tendency for the freshly cut set to have outyielded the stored cut sets both in No. 1's and in total yields. Few of the differences in yields of No. 1's are significant, while most of those in the total yields are significant but not markedly so. The results of this study apparently substantiate those which preceded.

THE 1927–28 STUDY

Smooth Rural seedstock was used in this study. The storage period was 179 days. There were no losses due to rots. The weight losses from shrinkage were greatest in those lots cut during the first 70 days of storage. It is also of interest that the check lots shrank most during this same period, with little loss thereafter. The cut stock lost at least five times as much weight from shrinkage during the storage period as did the uncut stock. Because the storage behavior of the seedlots of this and the 1928–29 study are so similar to that of 1926–27, figures which show details are omitted. Shrivelling and a pronounced darkening of the cut stock occurred in the four lots longest in storage; however, none of the sets of these lots were in poor enough condition to be discarded at planting time. The cut surfaces of the remaining cut lots were somewhat darkened and lacked firmness to a slight degree, the gradation depending directly on the length of time they had remained cut in storage.

The field trials were planted on a sandy loam soil of good fertility and consisted of five replications. A stand count was made on July 31, the results of which are given in Table 5. The differences in per cent stand in all cases are significantly in favor of the plats planted with freshly-cut seedstock with the exception of the seed lots which

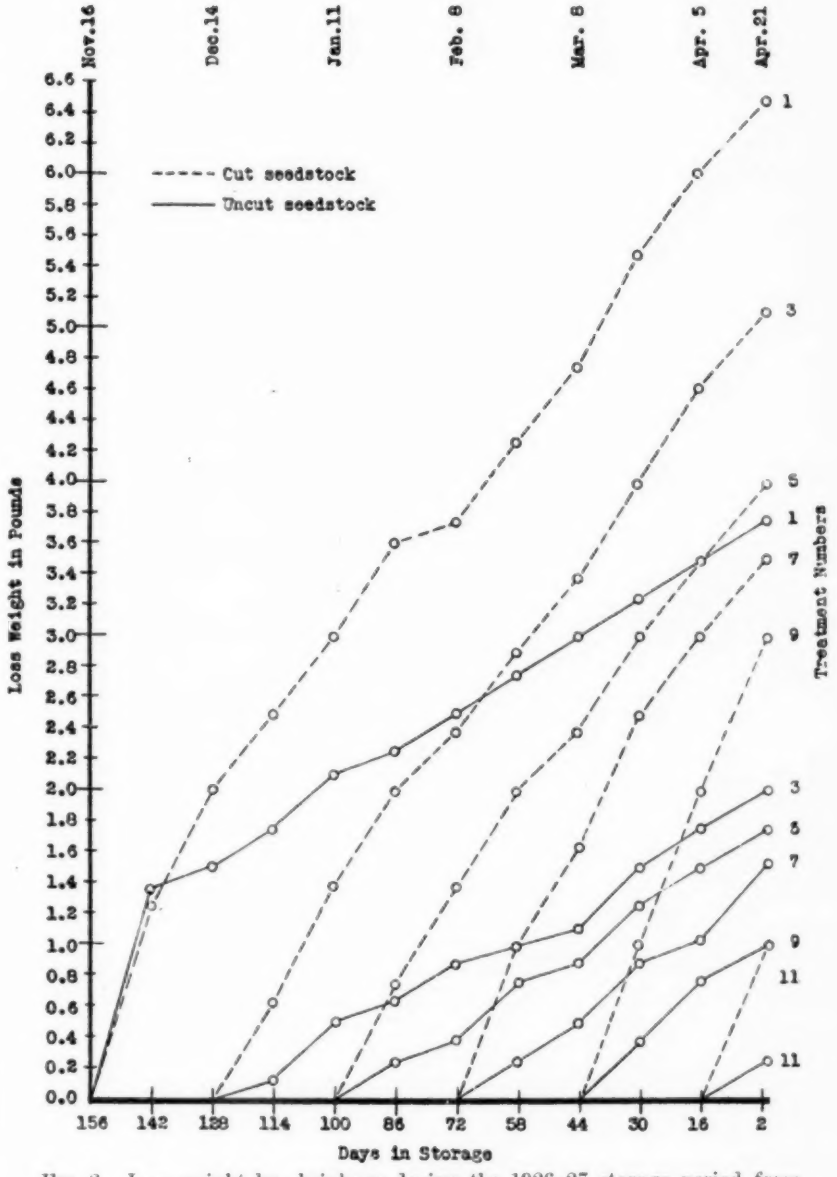

FIG. 2. Loss weight by shrinkage during the 1926–27 storage period from 30-pound cut and uncut seedlots.

remained cut in storage 147 days and 7 days, respectively. These seed-lots gave uniform stands, but the differences were not significant. No cause or factor to account for the uniformly high percentage of stand from the cut seed stored 147 days could be determined. In the case of the cut seed lot which was stored only seven days, it is probable that the storage period was too short for great enough change to occur in the sets to affect markedly their vitality.

At the same time the stand data were taken, an attempt was made to determine the relative vigor of the plants from the different cut

TABLE 5.—*Comparison of plant stand in percent from stored cut and freshly cut potato seedstock taken July 31, 1928*

Planting sequence of treatments	Date of Cutting	Number of days cut in storage	Comparison of treatments with mean of nearest flanking checks		
			Mean of stands of nearest checks in percent	Stand differences in percent	Odds
Check	5/14/28		93.9*		
1	11/21/27	175	83.3	+10.6	151
2	12/5/27	161	82.9	+11.5	88
Check	5/14/28		94.4*		
			95.4*		
3	12/19/27	147	88.7	+ 6.7	28
4	1/2/28	133	73.7	+22.2	184
Check	5/14/28		95.9*		
			96.4*		
5	1/16/28	119	75.4	+21.0	4999
6	1/30/28	105	80.2	+16.0	2499
Check	5/14/28		96.2*		
			95.5*		
7	2/13/28	91	78.3	+17.2	551
8	2/27/28	77	75.8	+20.2	2449
Check	5/14/28		96.0*		
			96.8*		
9	3/12/28	63	82.3	+14.5	Abs. Sig.†
10	3/26/28	49	84.6	+12.0	Abs. Sig.
Check	5/14/28		96.6*		
			96.5*		
11	4/9/28	35	82.7	+13.8	Abs. Sig.
12	4/23/28	21	82.3	+12.7	1249
Check	5/14/28		95.0*		
			94.5*		
13	5/8/28	7	90.6	+ 3.9	15

* Planting in several parts which resulted in different combinations of check rows.

† Abs. Sig. means absolute significance.

lots by a comparison with the nearest flanking check. The estimate was expressed in per cent based on the condition of the check lot. Although this method is obviously approximate the results closely follow those obtained from the stand counts in that, with few exceptions, the check plants seemed to have the greater vigor.

No yield data are available for this study because of the total destruction of the harvested yields by fire. The meager results obtained seem to support those of the other studies thus far carried on.

Because of the close agreement of the results of the 1928–29 study with those that precede, it is omitted from this report.

DISCUSSION

In the first (1921–22) and third (1926–27) studies, sets which were extremely withered and discolored were removed before planting time from certain of those cut seedlots longest in storage. Tables 2, 3, and 4 show that even with the removal of these portions, assumed to be worthless, these seedlots failed to compare favorably in field performance with the check seedlots.

In these studies the cut areas appeared to be well healed but the continuous loss of weight by shrinkage did not cease. Apparently suberization was "patchy" and incomplete during the entire storage season. It is regretted that tests to determine the rapidity and completeness of suberization were not made.

It has been quite apparent that the vitality and the yields of the plants from the different seedlots were closely correlated with weight losses in storage due to shrinkage, since only in very few instances have the stored cut seed proved superior to the freshly cut stock. The disagreement in the trend of the yields of the 1922–23 experiment as contrasted with the others, together with the consistency of the storage and yield data from these studies, suggest that possibly certain strains and varieties might lend themselves more readily to this practice than would others. In fact Weiss and his associates go so far as to suggest that the rapidity of wound periderm formation and suberization should be one of the characteristics having bearing on the introduction of new varieties of potatoes.

The stage of maturity of the tubers might be expected to influence the rate and completeness of suberization. Concerning this, Artschwager (16) found that different tubers often reacted differently under identical conditions.

These studies, the majority of which were completed before much detailed information on wound periderm formation and suberization was available, substantiate in part the results of the recent investigations in showing that Rural sets cut under ordinary storage conditions yield less than freshly cut stock.

SUMMARY

Studies to ascertain the possibility of holding potato sets immediately after they were cut in cold storage were in progress at this Station during the storage and growing seasons of 1921–22, 1922–23, 1926–27, 1927–28, and 1928–29. White and Russet Rural seedstocks were used. Seedlots of a definite weight cut periodically during the storage period were compared with check or uncut lots of equal weight to determine the losses due to shrinkage, disease and other causes. The condition of the sets of the different seedlots was compared at each cutting.

Storage losses due to shrinkage were greatest in those seedlots cut during the first eight weeks of the storage season, and the degree of these losses was of about the same magnitude. Shrinkage in the lots cut later gradually decreased according to the length of time they were in storage. During the comparable period the uncut seedlots also showed greatest losses in weight, which were in most cases less than one-fifth that of the corresponding cut seedlot. The losses due to shrinkage of the cut lots stored during the entire storage periods of the five studies varied from 12.2 to 27.7 per cent, while those in uncut seedlots varied from 3.3 to 12.0 per cent.

It is apparent from a general consideration of these studies that the length of storage period did not entirely influence the shrinkage, since maximum losses did not always occur in the studies with the longest storage period. The callousing of the sets appeared to have been completed in about four days under the existing storage conditions and in only one instance was a marked withering and blackening of the cut surfaces of the sets observed in those lots remaining in storage less than 100 days. The discoloration of the corked areas of the seedlots cut during the last half of the storage period was less intense as the storage period shortened.

Observation and actual comparative estimates of plant vigor generally favored the sets cut immediately before planting. Stand estimates and counts, yields of No. 1's, and total yields taken during the course of these studies favored the freshly-cut seedstock. Wherever these differences failed to favor the check seedstock they were generally of little or no significance.

It is concluded from these studies that under the existing conditions, Rural potato seedstock which is cut during the storage period and immediately subjected to general storage conditions may be expected to give poorer stands of weaker plants and lower yields than will result from the use of freshly cut sets.

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POTATO VIRUS DISEASES IN 1932

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This review represents the contents of over 100 papers, abstracts, and reports which deal with potato viroses in a way that may be of interest to either the practical grower or the scientist. It does not cover papers published or already abstracted in the AMERICAN POTATO JOURNAL or in the 1931 *Proceedings,* and continues a similar one for 1931 by the writer. Literature cited is given at the end according to authors, whose names are used for reference in the text. Each reference is dealt with only once, for economy of space, although a result is a certain looseness in the organization of the data given in the review. Economy also requires mere listing of many interesting articles.

SPINDLE TUBER AND LEAFROLL

Verplancke (Étude, etc.): In Maine, spindle tuber lengthened cells or reduced their width or both, in aerial parts, especially in the conducting system.

Whitehead, *et al.*: In Wales, leafroll apparently increased less with seacoast reduction of aphid abundance, of abundance of fields, and of length of life of the vines. A German book by Esmarch on leafroll discusses the disease thoroughly and explains the maintenance of the two causation theories, virus and physiological, on the basis of both being correct in Germany at least.

MOSAICS AND CALICO

Van Poeteren (p. 58): In Holland, mosaic by July 5 was in tubers of healthy fields growing near to mosaic stocks, and here increased from 6 per cent to 26 per cent by July 26 and to 32 per cent by September 22.

Porter: In California, calico is tuber-perpetuated and is infectious through leaf-mutilation, needle-pricks, tuber-grafting, and some field agent.

MASKED MOSAICS

Skinner and Reed (p. 21): In Indiana, potato seedlings when inoculated from apparently healthy potatoes of standard American varieties, vary in reaction from being symptomless carriers, like the commercial varieties, to showing severe necrosis. Burnett and Jones: In Washington, the "latent virus" was present in 654 of 655 tested tubers from six commercial varieties, and was absent from 52 seedling potato plants. The latent virus survives drying longer than the vein-banding virus and is transmitted differently mechanically. The former with tomato mosaic causes tomato streak in greenhouses, and, in a

virulent form, with the veinbanding virus causes a disease that resembles rugose mosaic.

Drinkard (p. 31): In Virginia "the virus occurring naturally in apparently healthy potato plants is regarded as being entirely different from the tobacco ring-spot virus."

DISSEMINATION

Cleveland: In Indiana, leafroll spreads variably but generally rapidly, the latter due more to spinach aphids (*Myzus persicae*) and potato leafhoppers (*Empoasca fabae*) than to the less abundant pink and green potato aphid (*Macrosiphum solanifolii*). Flea beetles (*Epitrix cucumeris*) and *Thrips tabaci* did not transmit. Spraying with a combination of Bordeaux mixture, lead arsenate and nicotine sulphate reduced leaf-hopper infestation and the spread of leafroll.

Cottier: In New Zealand, leafroll was transmitted by the aphid *Myzus persicae* but not by the aphids *Myzus solani* (*pseudosolani*) and *Macrosiphum gei*, the Jassid *Erythroneura zealandica*, *Thrips tabaci*, and the Lathridiid *Melanophthalma gibbosa*. Bryan: Disease increased less in Scotland than in England, even though the potatoes were rogued and dug early in England. Leafroll apparently was transmitted 750 feet in one place and over a mile in another. "There is evidence to show that aphis are capable of travelling great distances —800 miles has been known" (p. 363; referring, according to correspondence, to a note in *Nature* 126: 188–189, 1930).

CONTROL

In Idaho (Idaho A. E. S., p. 34), masked viroses need to be eliminated by greenhouse tuber indexing, but high altitudes help, apparently due to the lower temperatures there decreasing the abundance of certain insect vectors.

Verplancke (Exp., etc.): In Belgium the selection of large *vs.* small tubers usually had no effect, and had no consistent effect, upon the amount of mosaic, mottling, or leafroll. Riha: In Czechoslovakia, mosaic hastens the appearance and growth rate of sprouts, and leafroll slows their growth, but because of individual tuber variation the differences are too small to serve for diagnostic purposes. Magee: In New South Wales, Australia, tubers that sprout weakly in the dark include many that are leafroll. Isolation of the seed plot by only 100 yards is tolerable, and so is roguing 25 per cent of the hills, but not seed-plot work in the coastal regions where degeneration is faster than on the tablelands due to greater prevalence of insects favoring increase of mosaic and leafroll.

IDENTIFICATION, NOMENCLATURE, AND CLASSIFICATION

Cardon: In Utah, certain localities "can be relied upon to give full expression of the various virus diseases: Rugose, crinkle, mild and

leaf-rolling mosaic, as well as leaf roll and spindle tuber'' (p. 49). In psyllid yellows on the potato the nature of the infectious material may not be a virus (p. 54). Murphy and McKay: In Ireland, in spite of European simple mosaic in all, and European streak in most, of the tested American potatoes, comparisons using intervarietal inoculations showed that certain American viroses are respectively identical with European, as follows: leafroll—leafroll, Aucuba mosaic—Aucuba mosaic, interveinal mosaic—interveinal mosaic, witches-broom—wilding; probably mild mosaic—crinkle, leafrolling mosaic—para-crinkle; possibly giant hill—bolter. American diseases with no European counterpart are crinkle mosaic, rugose mosaic, American streak, spindle tuber, and yellow top. ''In Europe it has been found possible to select plants of a considerable and growing number of commercial varieties in which no virus can be found by any test yet devised'' (p. 348).

ENVIRONMENT AND CHEMICAL COMPOSITION

Wilson lists several dozen references on environmental factors in relation to potato viroses. Neuweiler (p. 517): In Switzerland, heavier soils increased mosaic and leafroll and amount of disease influenced yield rate. Quanjer (Die Sel., etc.): In Holland, nitrogenous fertilization favored virosis development (after inoculation) and increased spread, while potash had opposite effects, through affecting aphid propagation and virus diffusion. Crinkle, leafroll, mosaic, pseudonetnecrosis, and streak were studied.

Robertson and Smith: In Scotland, tuber pH was reduced by mosaic and crinkle and increased by leafroll. Hey: In Germany, electrical potential (calomel electrode) in tubers was generally greater with leafroll, mosaic, curly dwarf, etc., but in individual tubers could not distinguish between those with different diseases or, in the intermediate zone, between diseased and healthy tubers.

DEGENERATION

Marx and Merkenschlager in Germany expound the ecological degeneration of potatoes as due to a disturbance of the relations between water, salts, and colloidal plant structure. This theory seems to be based on modifications of virosis symptoms by environmental factors, on various biochemical studies, and on devious arguments, but to the reviewer the illustrations and descriptions indicate that the place of study (Dahlem) is a hotbed of virus diseases, as experimental grounds often are. Merkenschlager (1931) in a lengthy historical discussion attributes both mosaic in Great Britain and leafroll in Germany to lack of water balance in the plant.

Appel in summing up ten years' work at his institute (Dahlem) claims (pp. 49–50) that lack of means prevents a study of the virus

theory there. He attributes leafroll, curly dwarf, and mosaic to both viruses and physiological degeneration. Chemical analysis can not yet distinguish between healthy and diseased tubers because of intratuber variation. Klapp believes that in addition to transmissible viroses there are other causes of degeneration manifested in forms that are more or less perpetuated and that are reversible.

NATURE OF A VIRUS

Clinch of Ireland, in connection with a detailed description of the cytological characteristics of virotic potato plants, tolerates both the enzyme and the ultramicroscopic-organism theories (p. 161). Salaman adds virus "Z" to Smith's X and Y, describes their effects singly and in combination, and admits (pp. 201–202) that each may be a combination of viruses. With respect to the enzyme-organism controversy he suggests (p. 221) that "the viruses may be living organisms which have acquired, perhaps by the very reason of their extremely minute size, special relationships between themselves and their environment which allow of the building up of groups or complexes capable of existing and multiplying as such within a given environment." He cites and explains instances of partial recovery from viroses and of their apparently spontaneous appearance.

COMPARATIVE PATHOLOGY

Dufrénoy reports briefly on the proceedings of a congress of comparative pathology held in Paris in the last part of 1931. In the two volumes resulting from this congress (Congrès, etc.) are papers on potato viroses.

GENERAL PAPERS

Linfield (p. 17): In Montana, "virus diseases of potatoes probably cause a greater loss to that industry . . . than the combined loss from all other potato diseases. The reduction in yield caused by viroses may run all the way from 10 per cent to 100 per cent." McKay and Dykstra found, in Oregon, mild, interveinal, rugose, crinkle, and leafrolling mosaic, calico, leafroll, witches' broom, spindle tuber, and giant hill. Interveinal mosaic reduced yield 20 per cent, mild mosaic 40, crinkle mosaic 60, and spindle tuber 70. Irish Cobblers were immune to mild mosaic. Streak was absent, but streaking was a current-season symptom of rugose mosaic. Leafroll was transmitted by aphids more readily than other viroses, and more readily by some species than by others. For control, tuber-indexing is impractical, hill-indexing unreliable, and roguing of tuber-unit seed plots most practical. Details of inoculations with leaf mutilation, *Myzus pelargonii, M. circumflexus,* etc., are of interest.

In a description by Koeslag of certification in Holland, streak is said to be less abundant than leafroll and mosaic while "gelbfleckigkeit" (Aucuba mosaic?) is common but without noticeable effect upon the yield. It is no longer believed that viroses are perpetuated in the soil, except in diseased tubers. Recovery of completely diseased stocks is impossible, but a fraction found still healthy can be used to save a variety. Viroses are controlled by certification, selection, and early digging together. Mosaic increases generally more in sandy or moor soils than in clay soil, the clay being along the sea coast. Studies of masked viroses have already resulted in modification of the certification rules. Other general and well-known topics are also discussed.

Quanjer (Die Aut., etc.) discusses potato viroses with respect to field dissemination, insect transmission, influence of climate and soil, infection with juice, obligate parasitism, nomenclature, and classification. He admits the difficulty arising from the inability to see the virus or to culture it. He correlates spread of virus diseases with the prevalence of the peach or spinach aphid (*Myzus persicae*). He discredits earlier claims of soil transmission. He takes issue with certain German research workers and points out that the German seed industry might improve if the German ecological-degeneration theory were abandoned and more work done to control virus diseases.

MISCELLANEOUS

An extensive report from Great Britain (Min. Agr.) mentions results from a number of laboratories. At Cambridge, England, virus-free stocks of eight varieties, and probably 6 more, have been isolated and multiplied (p. 101). In field tests these virus-free stocks are remarkable for their vigor and production (p. 102). Leaf roll is transmitted by *Myzus pseudosolani* and *M. circumflexus* (p. 103). A new virus discovered in the dandelion (Taraxacum) can be transmitted to potato (p. 103). (See also pp. 39–40 and 210.)

In Canada (Güssow, 1931, pp. 154, 156–157) "tests failed to disclose any apparent connection between . . . stem and browning and such diseases as mild and rugose mosaic, leaf roll, spindle tuber, curly dwarf, spindle sprout, and net necrosis." In enzyme studies, "the rate of starch hydrolysis was less in the juice of the foliage infected with rugose mosaic, streak, witches' broom and spindle tuber compared with the juice from healthy foliage grown under the same conditions. No significant differences were found in the juice expressed from healthy compared with virus infected tubers."

In Maine (Maine A. E. S., pp. 194–198) mosaic was held to 3 per cent during several years by roguing an isolated tuber-unit seed plot of Green Moutains, while it increased to 98 per cent in two years of no roguing with a corresponding reduction of yield from 503 bushels an acre to 437. "A two-man planting machine can be used satisfactorily

for planting tuber-unit seed plots." Other seed plots and other varieties have been handled in similar fashion with a resulting maintenance in healthy or nearly healthy condition. At the first roguing in 1930 in central Maine, leafroll had already spread from diseased units, the plants were only a few inches high, and aphids were present. Still greater spread occurred later from units that were not rogued out, when wingless aphids were abundant. Spindle tuber spread several hundred feet to a healthy tuber line. Potato aphids (*Macrosiphum solanifolii*) transmitted leafroll less with older plants or with smaller numbers of transferred insects. Negative results were obtained with leafroll in transmission experiments with tarnished plant bugs (*Lygus pratensis*) and flea beetles (*Epitrix cucumeris*) and with contact of foliage and roots. Under certain conditions three kinds of aphids varied in power to transmit, *M. Solanifolii* lagging with mosaic, and *Myzus persicae* alone succeeding with leaf roll and spindle tuber, the third species being *Aphis abbreviata.* Flea beetles transmitted spindle tuber but not mosaic. The tarnished plant bug failed with spindle tuber. The potato beetle (*Leptinotarsa decemlineata*) transmitted spindle tuber. *M. solanifollii* failed with "the latent virus."

Individual tuber variation prevented the practical use of tests of loss of weight, resistance to alternating current, generation of direct current, refraction of light by soluble solids, resistance to a pressure tester, and acidity of the juice, to detect leafroll, mild mosaic, rugose mosaic, and spindle tuber, in the dormant tuber following the season of first infection. Mealiness upon cooking was not affected by these diseases but percentage of starch in the tuber was reduced by them. Irish Cobblers and Spaulding Rose are immune to mild mosaic and so are some new seedlings.

Mann (p. 67): In New York, greenhouse indexing of Smooth Rurals demonstrated an average of 30 per cent mosaic in certified stocks. Mosaic reduces the yield about 16 per cent though masked in the field. Aphid abundance influences, but does not determine, virosis increase in certified stocks.

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